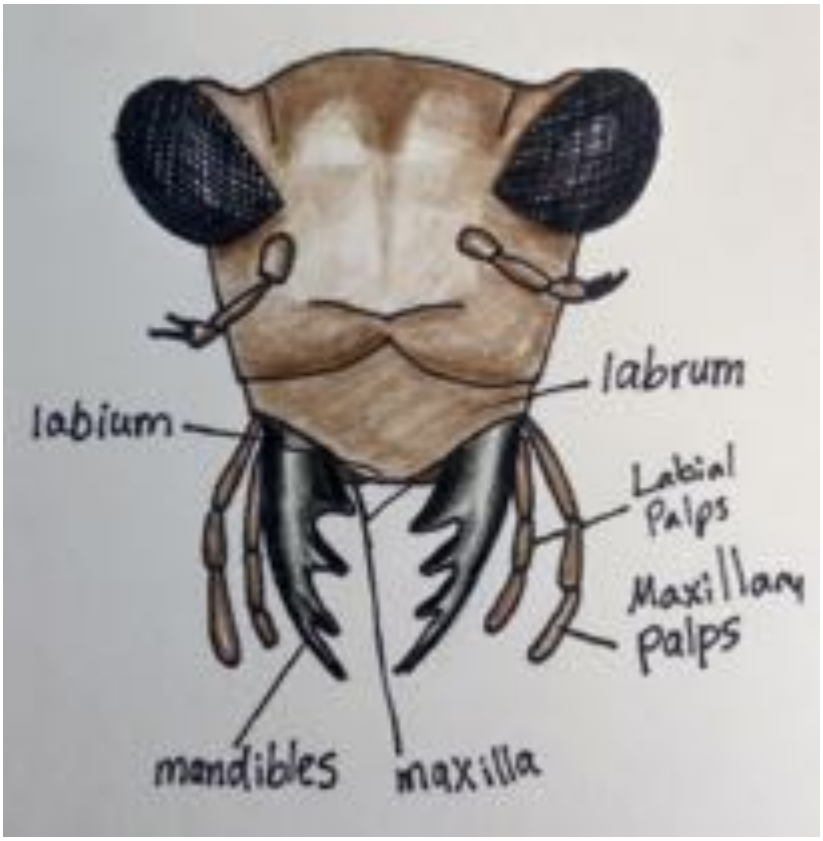
Activities for investigating Insect-Plant interactions

The following set of activities was developed for 7th and 8th grade students as a way to introduce them to insects, their interactions with plants, and the scientific method. The activities can be done independently or combined together depending upon what an instructor would like their students to learn. The first 3 activities contain all the information and instructions necessary to be complete each activity. Activity 4 will require the instructor to procure supplies that are readily available and at any local grocery store.

These activities are freely available for anyone that would like to use them and were made possible as part of a grant from the National Science Foundation.

Questions about the activities can be directed to Dr. David Althoff, Dept. of Biology, Syracuse University, dmalthof@syr.edu.



Plant-feeding insects and plants

By completing the four activities below, you will gain an understanding of how the interactions between insects and plants have influenced changes in each of these groups. You will examine how diet influences the mouthparts of insects, how the type of interaction can cause simultaneous changes in different insect structures, and some of the ways in which plants defend themselves from insects.

Activities:

1. **How do insects eat?**
2. **Changes of insect mouthparts throughout history**
3. **Adaptations to plants: pollination and herbivory**
4. **Plant Defensive Chemistry**

Name:_____

Activity 1: How do insects eat?

Name:_____

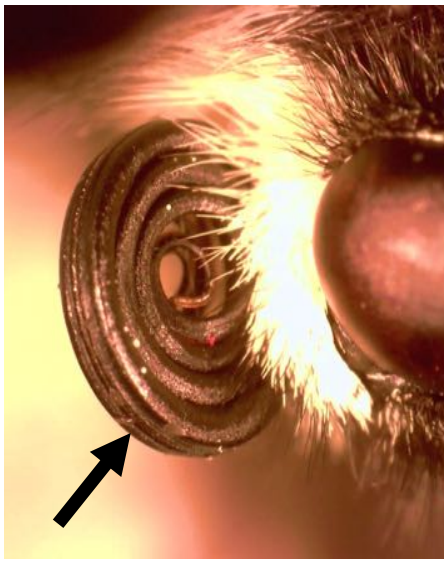
Read the short paragraph below about insect mouthparts and then complete the table.

> Insects have a many different feeding styles that are associated with the shape of the mouthparts. For chewing insects, the food has to be clipped off. If a chewing insect is carnivorous, the mouthpart will be knife-like to slice the tissue and if it is herbivorous, it will be broad and flat for grinding plant tissue. For piercing/sucking insects, the mouthparts are modified to form a feeding tube. The feeding tube contains a needle that pierces plant and animal tissue so that the insect can suck out the liquids. Piercing/sucking insects that feed only on the fluids of plants usually have a shorter, less stiff tube to pierce the plant. Those that pierce animals have a feeding tube that is generally longer and stouter to pierce through hard skin. Some of these insects, like female mosquitoes, inject saliva into their victim to keep the blood flowing and suck out the blood through another tube. Siphoning insects usually have no hard needle to pierce tissues; instead they use their long, grooved, and curled mouthparts to draw up nectar and other liquids. One species of siphoning insects, the vampire moth, has the ability to pierce through animal skin because it has hooks on its long mouthparts. A typical sponging feeder is the housefly that has sponging mouthparts, which sop up liquids and secrete saliva to dissolve solid food particles. Such flies usually cannot bite. Other flies, like the tsetse fly, have sharp teeth on the end of the sponge while other biting flies have knife-like structures above the sponge that cut flesh and release blood. These flies still feed by lapping up the blood with the sponging structure.

Fill in the following table using the above information on the characteristics of herbivorous and carnivorous insects of each group.

	Herbivorous	**Carnivorous**
Chewing		
Piercing/Sucking		
Siphoning		
Sponging		

Based on what you just learned about insect feeding types, examine the photos of insect mouthparts below and try to label each picture of an insect's mouthparts with one of the four major feeding types.



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_____

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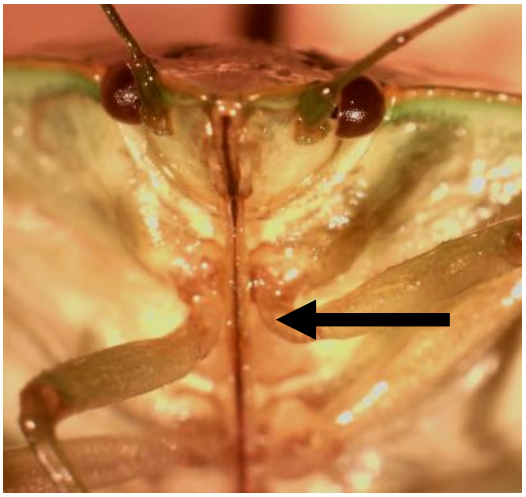

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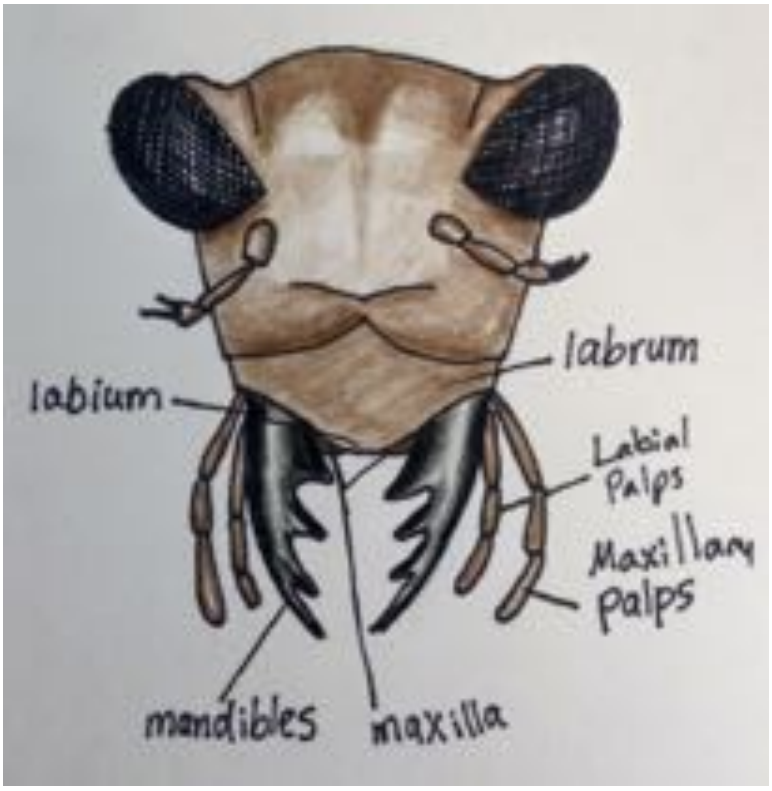
Name:_____

Activity 2: Transitions among insect mouthparts

The basic insect mouthparts

Insects have many parts that are used to obtain food as you can see from the drawing of a typical beetle head below. Each of these parts has a specific purpose in helping the insect acquire its food.



Mouthparts and their function:

Coverings:	*Labrum* - used to help cover and protect the attachment point of other mouthparts
	Labium - lower lip used to protect mouth opening
Sensory:	*Labial palps* - sensory organs
	Maxillary palps - sensory organ to test food
Feeding:	*Maxilla* - moves food particles into mouth
	Mandibles - capture food and break into smaller pieces

These mouthparts are what the ancestral insects had and all of the other feeding types have changed these and in some cases lost them through evolutionary time.

Activity 2: Transitions among insect mouthparts

Even though insects now feed in a variety of different ways, the first insects all had chewing type mouthparts. We would call chewing the ancestral condition for insect feeding. As insects evolved into new species and started using new food resources, there was selection for insects that had mouthpart variations that were better able to feed on new types of food. This lead to the four major feeding types for insects and also the differences you observed within each feeding type for carnivorous and herbivorous feeders.

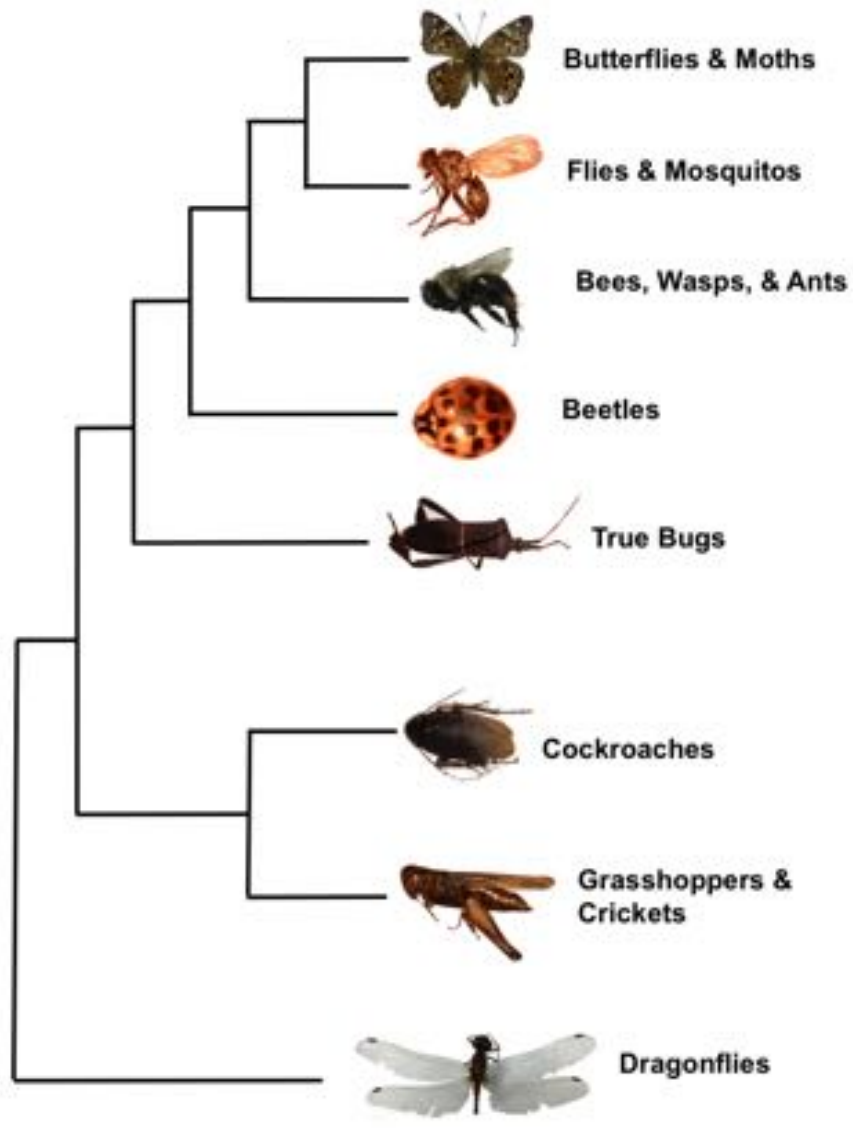
In the next two exercises, you are going to examine how insect feeding types have changed over time and then try to determine how each of the individual mouthparts from the chewing feeding style was modified to work in a different feeding style. First, you are going to learn the evolutionary relationships among some of the major insect groups and their feeding types.

Based on your own knowledge and experience with insects, try to identify the insect groups below and what feeding type each might have.

Activity 2: Transitions among insect mouthparts

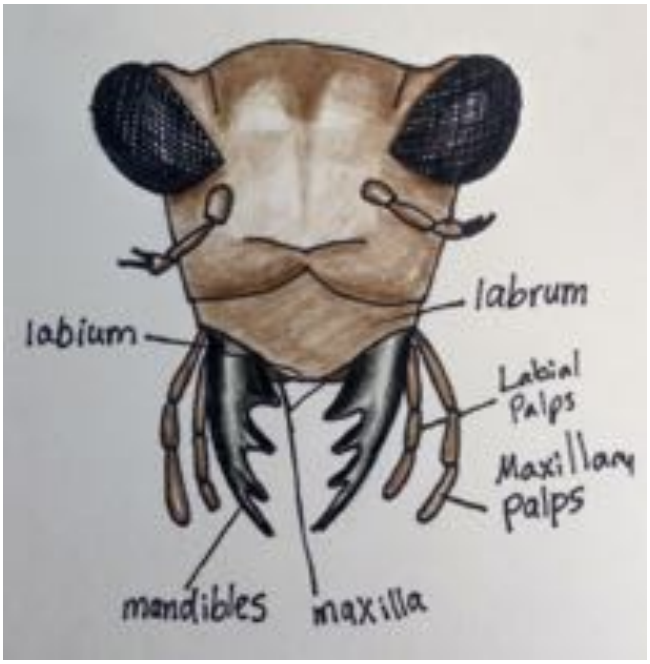
Below is a phylogeny or family tree that shows how the insect groups are related to one another. Dragonflies are the oldest group and butterflies & moths are the youngest group. Groups like butterflies and flies are each other's closest relatives.

Given what we determined about the feeding types for the groups, write down the feeding type next to each name. This will let us see how the feeding types have changed as insects evolved into new groups.

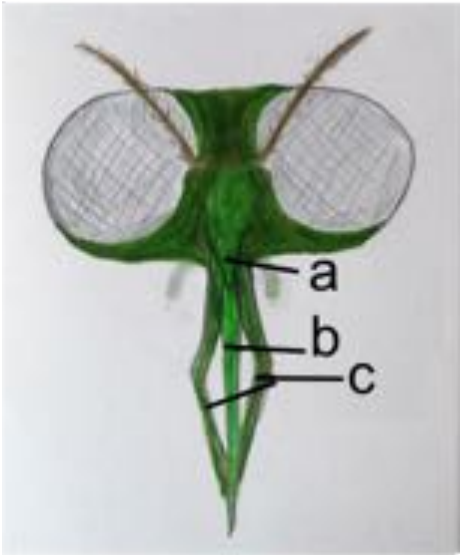


Activity 2: Transitions among insect mouthparts

Using the chewing feeding style as a starting point. Make an educated guess about what each of the mouthparts are for the piercing/sucking, siphoning and sponging feeding types. This may be hard to do since the mouthparts may have changed a lot, but try your best and see how many you can figure out.



piercing-sucking

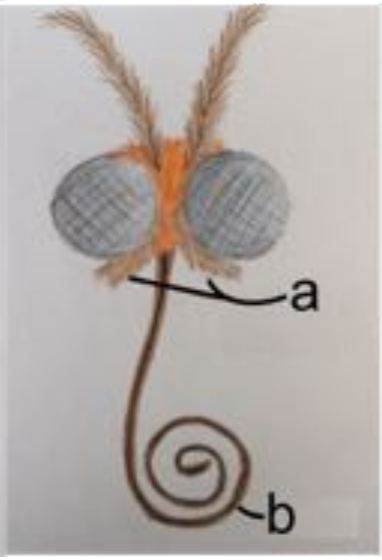


a._____

b._____

c._____

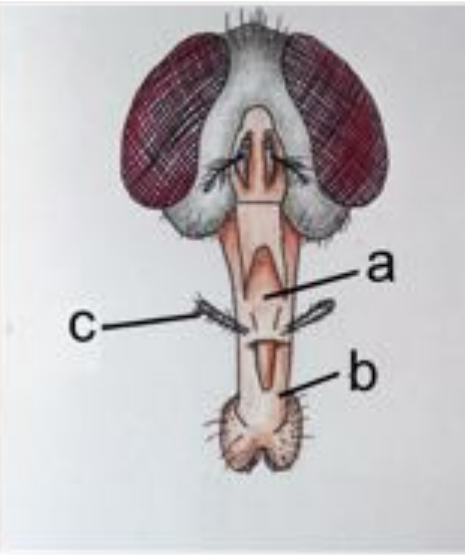
siphoning



a._____

b._____

sponging



a._____

b._____

c._____

Activity 3: Testing for adaptations to plants: pollination and herbivory

Many plants are pollinated by insects as a way to produce seeds. In 99% of the cases, the insect pollinates by accident as it is moving around the flower trying to get nectar. Think of a bee with its body covered with pollen. One group of moths has a special relationship with its plants. Yucca moths are the only pollinators of the flowers of yuccas, but they also lay eggs into the flower. The eggs hatch into caterpillars that then feed on the developing seeds. What is really amazing about the moths is that they have a evolved new mouth part called 'tentacles' that grows off the maxillary palp. Female moths use the tentacles to actively collect and place the pollen on the right place in the flower. By active we mean that they have behaviors in which they purposefully place the pollen rather than it falling off the moth by accident as it moves around the flower. So, yucca moths are both pollinators and herbivores of yucca plants.

Examine the photos on the next page. In center is a pair of female moths in a yucca flower. One of them is using the tentacles to jam the pollen into the flower, while the other ones is laying eggs into the flower. The photo in the upper left is a close up of a moth head's showing the tentacles. They are called that because they can roll up and unfold as they remove the pollen from a pollen ball that the moth carries under its head. Notice the moth laying eggs, she has a large yellow ball under her head. This is the pollen and you can see that the female at the top has placed some into the flower to pollinate it. The photo in the upper right is a close up of the egg-laying structure (called an ovipositor –'egg placer'). For these moths, the structure is like a fine needle that they pierce through the side of the flower to lay eggs next to the developing plant seeds. The caterpillars then feed inside the flower on the seeds until they are done and drop into the soil by chewing their way out of the fruit the flower developed into.

Goal:. In this activity, you are going to measure the length of the tentacles and the egg-laying structures for two different moth species that pollinate different plant species.. The photos you are going to use were actual ones produced by scientists studying the moths and were used to help publish a scientific article on the moths and plants.

After doing the measurements, try and answer the following questions:

1. What varies more in length between the species, the tentacles or egg-laying structures?
2. Why do you think that some species have long vs. short egg-laying structures?
3. If you were to think about which trait, tentacles or egg-laying structures, was changing more between moth species, which one would you choose? Why?

Yucca moths and their interactions with yucca plants

Close up of tentacles

Close up of egg-laying structure

This moth is pollinating with mouth parts called tentacles

This moth is laying eggs into the flower

The caterpillars feed on the seeds

Activity 3: Testing for adaptations to plants: pollination and herbivory

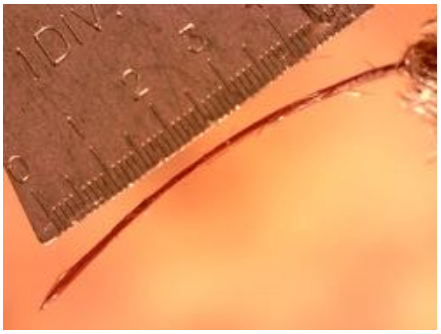
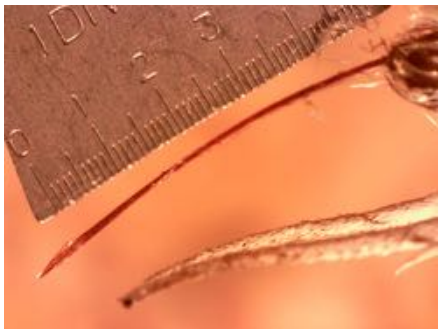
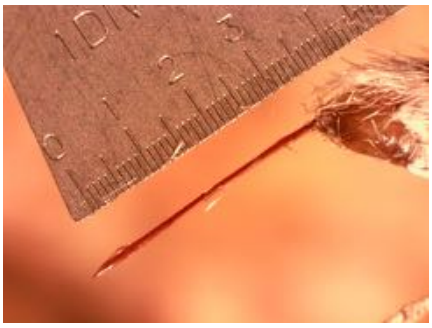
Below are two different species of moths that we are going to look at: Altiplanella (alti-pla-nella) and Elatella (ela- tella) that pollinate and feed on yuccas. Using the pictures provided, measure the tentacle lengths of individuals of both species and record them in the data sheet provided. You will have to decide where to start and end your measurements and do the same for each picture. A piece of string could be used to trace the structures and then measure against the rulers. Then, measure the length of the egg-laying structure. The goal here is to see if there is a difference between the species in each of the traits. If you find any differences, why do you think these differences are present and what do you think led to this difference?

Altiplanella:

Tentacles:



Egg-laying structures:

Each picture has a ruler in it so that you can estimate the length. In the top pictures the distance between two hash marks is 0.1 millimeters. In the bottom picture each number is a millimeter and the small hash marks are 0.1 millimeter.

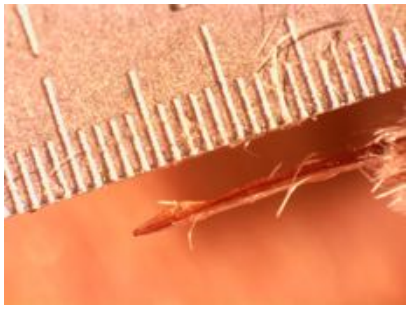
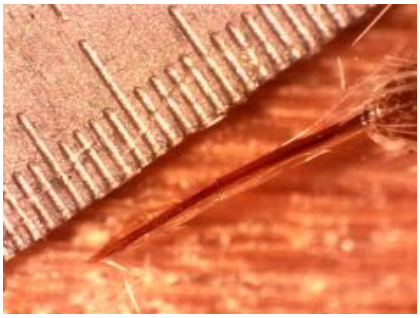
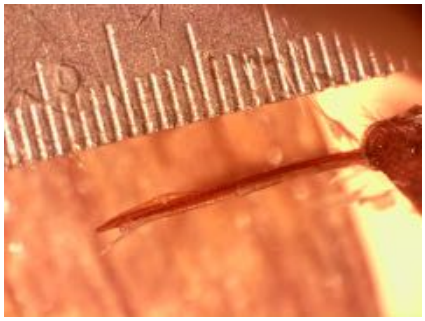
Activity 3: Testing for adaptations to plants: pollination and herbivory

Elatella:

Tentacles:

1)  2)  3) 

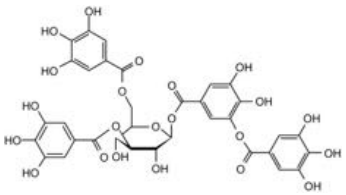
Egg-laying structures:

Data Sheet:

Species	Individual	Tentacle	Egg-laying structure
Altiplanella	1		
	2		
	3		
	average		
Elatella	1		
	2		
	3		
	average		

Activity 4: Plant defense against plant-feeding insects



In this activity we will explore three different chemical mechanisms by which plants defend themselves from herbivores. After reading the descriptions below of the different components used for defense, discuss them among your groups to understand the differences.

1.Saponins (sap-o-nins) : Saponins are chemicals that have the same properties as soap. Yuccas that you learned about in Activity 3 are sometimes called soap trees because they have a lot of saponins in their seeds. These substances have detergent (soap-like) properties and disrupt the cell membranes of insects.

2.Tannins (tan- nins): These are plant chemicals that dissolve in water and are stored in plant cells. When an insect bites into a leaf, tannins are released and bind to salivary proteins and digestive enzymes in the insect mouth and stomach. These de-activates the enzymes necessary to breakdown food. Insect herbivores that eat high amounts of tannins fail to gain weight and may eventually die. Tannins usually taste bitter to humans.

3.Capsaicin (cap-say-cin): Capsaicins are a plant chemical that is detectable by mammals, but not birds. In mammals, they produce the same pain response as heat. Birds, however, lack the pain receptors that capsaicin binds to. Birds can eat fruits that have capsaicin and help disperse the seeds.

Next, come up to the front table and take three cups (labeled A, B, and C) of varying plant material.

For cup A, use a mortar and pestle to grind up the plant material. Using your senses of smell and taste record what defensive compound you believe this plant is using.

For cup B, take the plant material, smash with the material with your fingers and put in the cup. Add a little bit of water so that it just covers the material. Pour the liquid through filter paper and into a clean cup. Based on the way this product feels, what defensive compound is used by this plant?

For cup C, place water in the cup and allow the plant material to absorb some of the water then filter out the excess material and taste the solution you've just made. Record what type of defensive compound you think it is.

Results:

Cup A:_____ Cup B:_____ Cup C:_____

Activity 4 Teacher Instructions

Materials:

1. Water
2. Loose tea
3. Coffee filters or filter paper
4. Any kind of Chili peppers
5. Mortar and pestle or something that students can use to grind up plant tissue
6. Dried lentil, soaked overnight in water

Cup A will be chiles Cup B will be soaked lentils Cup C will be tea

Set up:

1. Fill small plastic cups as per information above. For cup A, cut the peppers into slightly smaller pieces, so that the students are not able to immediately tell what it is.
2. Set up containers of water for the students to add to the plant tissues when it is time.
3. Lay out packs of filter paper for the students to use
4. Make sure every bench has their own mortar and pestle, and if not allow enough for sharing.
5. Once you have everything you need, lay the cups in sets of three (A, B, and C) so that students can come up and grab all three at once.
6. Have all of the other supplies ready at their benches (mortar and pestle, water, etc.) so they can begin running the experiments as soon as they receive the plant material cups.